

Tailor-Made Impurity Control of Elastic Versus Plastic Domain Switching in Ferroelastic Inclusion Compounds

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Abstract No. Ragh9958

Beamline(s): X19C

Introduction: A series of closely related inclusion compounds based on the urea channel framework undergo domain switching under applied anisotropic stress (ferroelasticity). Domain switching under stress can be plastic (newly formed domain does not spontaneously return to its original state when stress is released) or elastic (new formed domain returns to its original state when stress is released). Type of domain switching for a given compound depends on the orientation, dimensionality and cooperativity of specific hydrogen bonding networks. By growing crystals in the presence of tailor-made impurities, one can disrupt specific hydrogen bond networks and observe measurable changes in the kinetics and reversibility of the ferroelastic response. In this work, crystals of 2,10-undecanedione/urea containing various levels of 2-undecanone are subjected to various levels of stress and x-ray topography and videomicroscopy are used to monitor changes in the state of strain and domain switching.

Methods and Materials: Solid solutions of 2-undecanone and 2,10-undecanedione in urea containing different proportions of 2-undecanone and 2,10-undecanedione were crystallized from solution. The crystals were mounted on a goniometer placed in a setup designed to apply compressive stress perpendicular to the edge of the crystal. X-ray transmission topographs were recorded before application of stress and at each stage of stress application and release. Videomicroscopy of the samples was also carried out at the same time.

Results: In 2,10-undecanedione/urea crystals, twinning occurs across two different types of domain boundaries to give twelve sectors that are rotated approximately 60° from one another¹. This gives rise to three interference colors when the crystals are viewed between crossed polars with a lambda plate (Figure 1(a)). The twins can be characterized in an x-ray topograph by means of orientation contrast (Figure 1(b)). On application of stress, domain reorientation takes place. Figure 2 shows the optical micrograph and x-ray topograph after application of stress for 90:10 (2,10-undecanedione:2-undecanone)/urea. The domain orientation does not return to the original configuration (i.e. Fig. 1) indicating that the domain switching is plastic. Figure 3 shows x-topographs recorded from 82:18 (2,10-undecanedione:2-undecanone)/urea before, during and after stress application. In this case, domain orientation returns to the original configuration indicating that the domain switching is elastic. Similarly, optical micrographs and x-ray topographs recorded from the entire series of compounds were studied for the type of domain transition.

Conclusions: Using a combination of video microscopy and SWBXT, we have successfully characterized the type of domain transition in ferroelastic urea inclusion compounds. In 2,10-undecanedione + 2-undecanone /urea inclusion compounds, the domain switching changes from plastic type to elastic type as the impurity concentration is increased from 0 to 20%. Point of transition was found to be between 14% and 18% 2-undecanone.

Acknowledgments: Research supported by NASA and NSF. Topography carried out at the Stony Brook Synchrotron Topography Facility, beamline X19C at BNL, which is supported by the DOE.

References: ¹ H. Chung, M. Dudley, M.E. Brown, M.D. Hollingsworth, *Mol. Cryst. Liq. Cryst.*, **276**, 203, (1996).

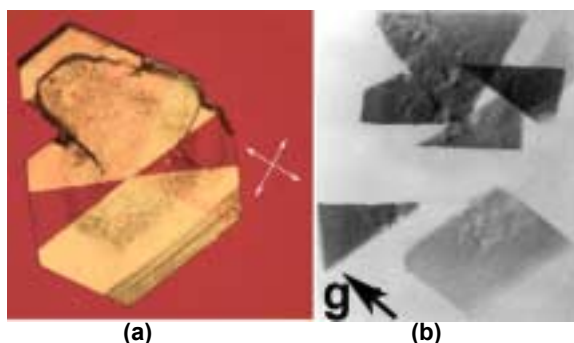


Figure 1. 90:10 (2,10-undecanedione:2-undecanone)/urea (no stress). (a) Optical micrograph with lambda plate; (b) X-ray topograph

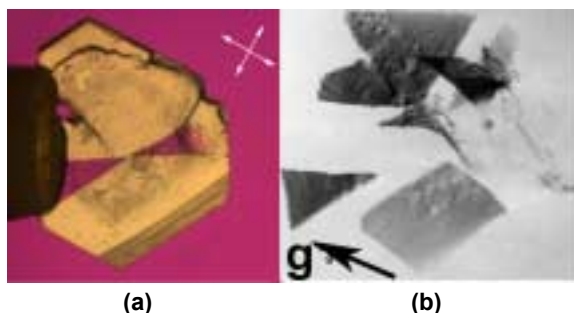


Figure 2. 90:10 (2,10-undecanedione:2-undecanone)/urea (112cN stress). (a) Optical micrograph with lambda plate; (b) X-ray topograph

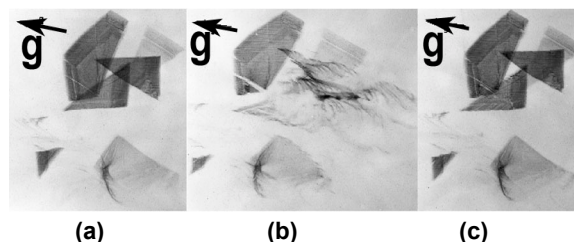


Figure 3. 82:18 (2,10-undecanedione:2-undecanone)/urea x-ray topographs (a) no stress; (b) 91cN; (c) after 91cN